EXPERIMENTAL PREPARATION OF RAISED BOG REHABILITATION IN THE PROCESS OF PEAT-CUTTING

Romas Pakalnis, Jūratė Sendžikaitė, Dalia Avižienė

Laboratory of Landscape Ecology, Institute of Botany, Žaliųjų Ežerų 49, LT–08406, Vilnius, Lithuania,
E-mail: romas.pakalnis@botanika.lt
jurate.sendzikaite@botanika.lt
dalia.aviziene@botanika.lt

Introduction

Bogs cover 415 000 ha (6.4%) of the Lithuanian territory. Peat layer of industrial importance covers 237 000 ha, of which only 64 peat bogs have realistic exploitation resources with approximately 119 million tons of peat, which accounts for about 10% of all the Lithuanian peat resources. These data highlight a must to use peat resources and peat mining products economically and rationally (SAULĖNAS, 1996; SINKEVIČIUS, 2001). Other peat mining aspect unsolved legally is dehumidifying effect in the neighbouring territories. As concerns the latest technologies, peat mining is possible only if the water level in the peat bog is constantly lowered during the entire mining period.

The raised bog of Aukštumala is one of the first commercial mining peat lands in Lithuania since the end of the 19th century. Aukštumala (Augstumal) is a *locus classicus* of peat land science because it is the first raised bog in the world described in the monograph (WEBER, 1902*)*. More than 120 yearlong peat-cutting processes predetermined some complicated problems. Peat extraction in the eastern part of Aukštumala raised bog provokes draining of the neighbouring zone (50–100 m width) of Aukštumala Telmological Nature Reserve and gives raise to negative changes in hydrological regime and protected vegetation cover (spreading of forest communities, which are not characteristic to raised bog; growth of trees' annual radial increment; wilting and disappearance of plant species typical to raised bog; degradation of plant communities). The contact zone of the Telmological Reserve and peat-cutting fields is about 6 km long, therefore, 30–60 ha area is in the zone of draining influence. Keeping a balance between economical activity and natural ecosystems is one of the most sophisticated problems of social development. To solve this problem, modern world tries to apply the principals of sustainable development.

The main objective of the project is to work out and implement sustainable development programme for Aukštumala Telmological Nature Reserve based on new methods and principles that would enable to conform the most contradictory interests in protection of bog ecosystem and

peat extraction. Historically, the interests of bog conservation and peat mining are opposing in Aukštumala raised bog. On the one hand, it is essential to maintain water level favourable for bog formation in Aukštumala Telmological Reserve, and, on the other hand, it has to be constantly lowered in the mining fields.

Natural conditions and human impact on the raised bog of Aukštumala

The raised bog of Aukštumala occurs in the western part of Lithuania, in the interstream area of the rivers Nemunas and Minija. It looks like a right-angled triangle with rounded corners and ragged concave side, of which the hypotenuse lies to the southwest towards Lake Krokų Lanka. 1.6 m above bay sea level, the surface of the raised bog rises steeply to a height of 4.5–5.0 m above bay sea level in a 150–500 m (average 300 m) wide belt (WEBER, 1902; COUWENBERG, JOOSTEN, 2002). Morphogenesis of the separate parts of Aukštumala peat bed is different: the western part consists of glaciolimnic, lagoon and old valley sedimentation area, whereas the eastern part – morainic and glacioaqueous hollow relief; late ice lake and the Holocene bogging (KUNSKAS, 2005). It should be noted that the development of Aukštumala raised bog was influenced by the irregularity of its peat bed, which at present cause problems in peat extraction, and, surely, will have great influence on finishing of mining works and implementation of the projects on ecological restoration of raised bog in the future.

Peat litter in Aukštumala was excavated manually until World War II. The greatest changes in the raised bog of Aukštumala (3018 ha) took place in the Soviet times after 1968, when protective embankments, water pumping stations, roads and ditches were built, large area (2/3 of the total bog) was drained for mechanized peat-cutting. After the restoration of Lithuania's independence (1990), the Government established Nemunas Delta Regional Park (1992) with Aukštumala Telmological Nature Reserve (1017 ha) on the unexploited western part of the bog. Due to rare and protected plant species, communities and a large number of different hollow pools (>100), this territory was included into a list of NATURA 2000.

Material and methods

The scale of disturbance and degradation of plant communities and vascular plant species diversity in Aukštumala Telmological Nature Reserve was evaluated in 2005. Nomenclature of plant communities was applied following the floristic-phytosociological plants classification principles of Zürich-Montpellier school (BRAUN-BLANQUET, 1964; BALEVIČIENĖ, 1991; POTT, 1995; DIERßEN, 1996). Latin names of plants were presented following the checklist of Vascular

Plants of Lithuania (GUDŽINSKAS, 1999). Redlisted species were presented according to the Red Data Book of Lithuania (RAŠOMAVIČIUS, 2007).

The dendrochronological method (PAKALNIS, 1972, 1978; STRAVINSKIENE, 1994, 1997) was selected to measure changes in hydrological regime (since 1950 to 2005) of Aukštumala Telmological Nature Reserve. In 2006, wood samples (boreholes) were taken using Pressler's borer. In accordance to the methods of collecting experimental material for dendrochronological research, changes in radial increment of *Pinus sylvestris* L. trees growing in the raised bog were analysed.

Technical and technological solutions for installation of original water level maintenance system (1 km long) were suggested and implemented on the border of Aukštumala Telmological Reserve in 2006 (*Fig. 1*). To estimate the efficiency of this special equipment, a hydrological monitoring system (24 water level assessment wells distributed in 4 profiles) was worked out. Three profiles (I–III) were installed perpendicularly to the water levelling system. Control profile (IV Control) was equipped outside the boundary of the system, next to effectively functioning draining ditch (3.0 m depth). The measurements of water level were carried out in April–October 2007.

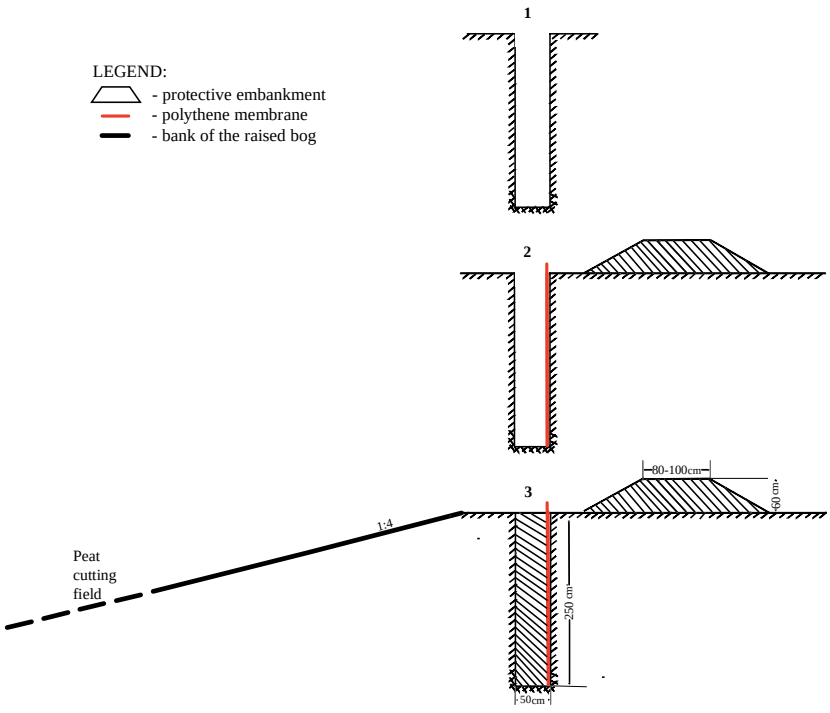

Fig. 1. Scheme of installation of the equipment of water level control:
1 – 2.5–3 m depth trench was excavated; 2 – polythene membrane was laid into the trench;
3 – the trench was filled up with raised bog peat

Peat-cutting effect upon on the vegetation of Aukštumala raised bog

At present time, the flora of Aukštumala raised bog is quite rich in spite of long-term (about 120 years) commercial peat-cutting and intensive land-reclamation. In 2005, about 150 plant species (57 % of all species characteristic to Lithuanian peat lands (264 species)) were found in the territory of Aukštumala Telmological Nature Reserve. The largest diversity of plant species was recorded on the fen and transition mire, which surround the raised bog. There are abundant species of *Cyperaceae, Poaceae* families, different species of *Salix* sp. and *Sphagnum* (*S. centrale, S. medium, S. angustifolium*). Communities of Ass. *Sphagnetum magellanici* (Malc.) 1929) Kästner et Flössner 1933 are prevailing in the open raised bog and only in the western part of the bog occur communities of Ass. *Eriophoro-Trichophoretum caespitosi* (Zlatn. 1928) Jenik 1961 em. W. Mat. 1974. All crooked dwarf forms of *Pinus sylvestris* L. (*f. uliginosa, f. litwinowii, f. turfosa, f. pumila, f. wilkomii*) were recorded in Aukštumala raised bog.

According to the List of Habitats of European Importance in Lithuania (RAŠOMAVIČIUS, 2001), the largest area of Aukštumala Telmological Nature Reserve is occupied by communities of active raised bogs (7110), included in Annex I of the EU Habitats Directive (92/43/EEC), with small fragments of degraded raised bogs still capable of natural regeneration (7120), natural dystrophic lakes and ponds (3160) and tracts of Fennoscandian deciduous swamp woods (9080) on the edges of the Telmological Reserve.

During the research period, 5 vascular plant species of the Red Data Book of Lithuania (RAŠOMAVIČIUS, 2007) were inventoried in Aukštumala raised bog: *Erica tetralix* L. (1 (E) category), *Dactylorhiza fuchsii* (Druce) Soó (4 (I) category), *Trichophorum cespitosum* (L.) C. Hartm. (2 (V) category), *Sphagnum molle* Sull. (2 (V) category), *Nymphaea alba* L. (3 (R) category). *Sphagnum imbricatum* Hornsch. ex Russ. was recorded in Aukštumala raised bog at the beginning of the 20th century (WEBER, 1902; JUKONIENĖ, 2003). Since then, it has been the only report about this species of bryophytes in Lithuania.

In the research period, the following changes in the vegetation of Aukštumala raised bog were ascertained: luxuriant cover of under wood in the communities of open raised bog; penetration of trees (*Betula pubescens* Ehrh. and tall-stemmed *Pinus sylvestris* L.) into *Ledo-Pinetum sylvestris* R. Tx. 1955 communities; spreading of under wood into the communities of hollows; extinction of bog moss and formation of lichen cover in the communities of open raised bog and those next to draining ditches; changes in plant communities are more intensive in the zones impacted by draining ditches and less intensive in the central part of the Telmological Reserve as well as on the western slope of the raised bog.

Hydrological changes in Aukštumala raised bog

The dendrochronological method was selected to measure radial increment of *Pinus sylvestris* L. growing in the raised bog. The radial increment of *Pinus sylvestris* L. trees growing in the zone under the impact of peat mining works was low until 1978 (it did not exceed 0.5 mm/year), whereas during the last 37 years it has increased by more than 4 times and reached 1–1.5 mm/year (*Fig. 2*). It was ascertained that peat extraction in the eastern part of Aukštumala raised bog provokes draining of the neighbouring zone (50–100 m width) of Aukštumala Telmological Nature Reserve and gives raise to negative changes in hydrological regime and protected vegetation cover.

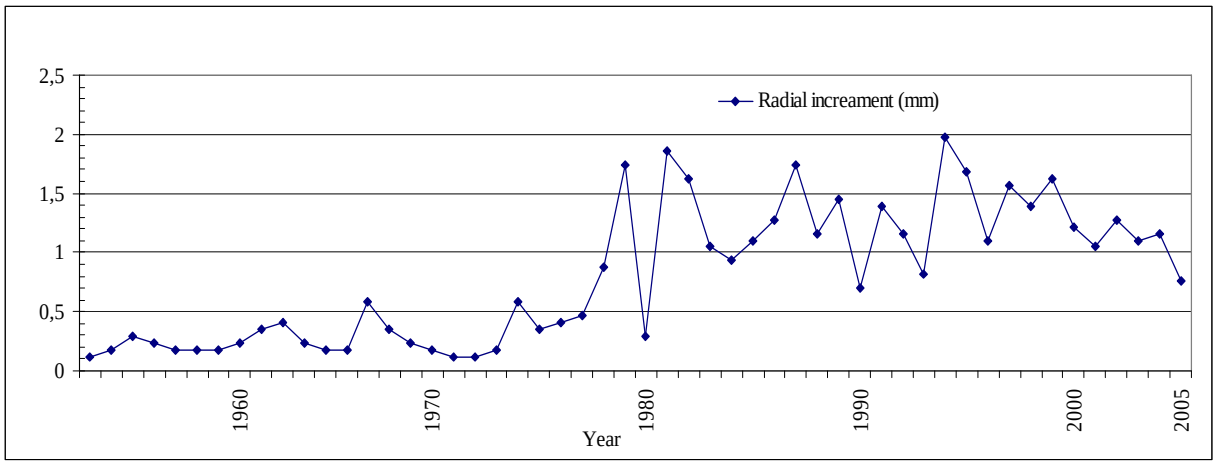

Fig. 2. Impact of habitat draining upon *Pinus sylvestris* L. radial increment, Aukštumala

The research data obtained in 2007 suggest that water level on the edge of the raised bog (near water levelling system with protective membrane) through the whole length of the profile was rather stable (depth 10–40 cm) (*Fig. 3*). In the 1st and 2nd wells of the control profile (IV Control), which occur the closest to the drainage ditch, water was much deeper (70–120 cm). Mean water level was successively decreasing from the central part of the bog (16.4±1.11 cm) towards the drainage ditch (95.1±4.80 cm). The decline coefficient of water level depression curve is 1.1 cm/m of profile length or 1.1%.

During the first years of exploitation (2007) of water levelling system, it turned out that water, which had accumulated on the side of the Telmological Reserve, was pressing the protective system with membrane towards the mining fields. This process was very clear, where the protective embankment and membrane were installed on insufficiently stable peat-bed or were crossing former deep pools (*Fig. 4*). Therefore, in the future, to install similar levelling systems, it is necessary to preserve natural peat-bed structure on a flat slope.

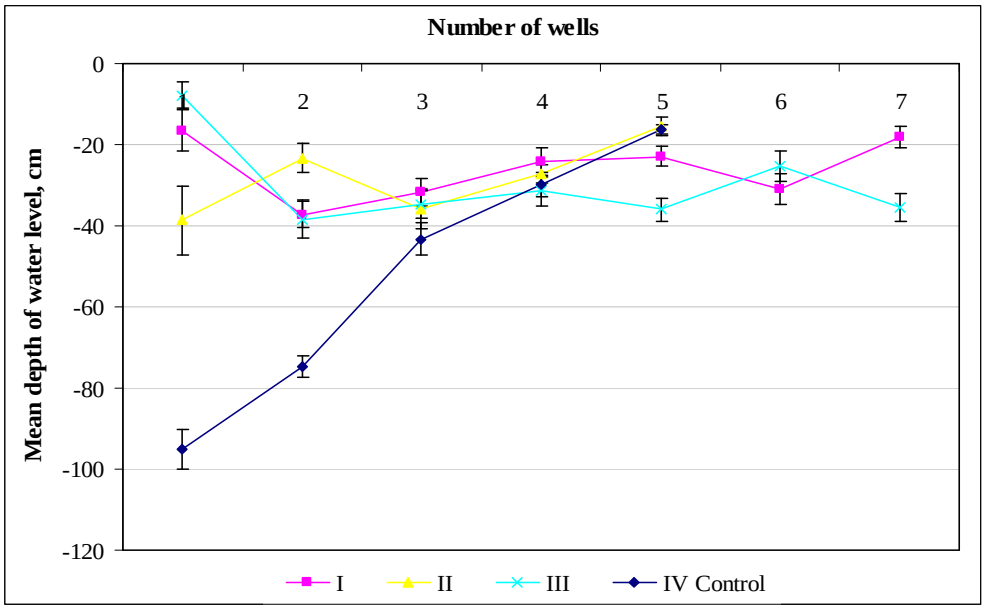

Fig. 3. Fluctuation of water level (Aukštumala, monthly measurements, January, April–September 2007):
I–III – with protective membrane; IV Control – without protective membrane

Fig. 4. Deformation of water levelling system, Aukštumala, in 2007

The monitoring of water level dynamics in 2007 enabled to assess hydrological efficiency of the established water levelling equipment. During the first year of observation, positive effect of the installed equipment was undoubted: water level on the edge of the Telmological Reserve was 80 cm higher than in control variant (IV Control – without protective membrane).

Conclusions

The main objective of the project on sustainable development of Aukštumala Telmological Nature Reserve is to work out and implement a programme based on new methods and principles that would enable to conform the most contradictory interests in the protection of bog ecosystem and peat mining. Draining effect of peat mining in neighbouring protected areas could be decreased by elaboration and implementation of special technical measures. Implementation of special measures of water level insulation provide creation of rather stable banks for the future bog restoration works in exploited part of the peat bog.

Even the first-year research-data show that the implemented water levelling system with a long lasting polythene membrane will be efficient and applicable within the zones of other environmental and peat mining conflicts. Already in the first year of exploitation (2007), this membrane played its part and sustained mean water level (up to 80 cm higher) on the edge of the reserve. Hydrological monitoring during one vegetation season show sufficient effect of implemented measures but a long-term observation of water level changes is necessary.

Long-term water level monitoring data will permit selecting techniques to hydrologically isolate the edges of other protected bogs from the impact of mining fields. In the future, to establish similar water levelling system and avoid its deformation, it is necessary to preserve natural and stable peat-bed structure of the flat slope. It is important to accomplish monitoring of hydrological impact of water levelling system upon water resources of the Telmological Reserve and estimate the possibilities of accumulation of water surplus. In case water would start flowing over the top of protective embankment, a 20 cm diameter pipe should be installed on the lower places of the embankment to flow down water surplus.

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